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(71)(72) Applicant and Inventor: BUCHANAN, Nigel, Alexander [GB/GB]; Beechtree Cottage, New Gilston, By Leven, Fife. KY8 5TF (GB).

(74) Agent: FITZPATRICKS; 4 West Regent Street, Glasgow G2 1RS (GB).

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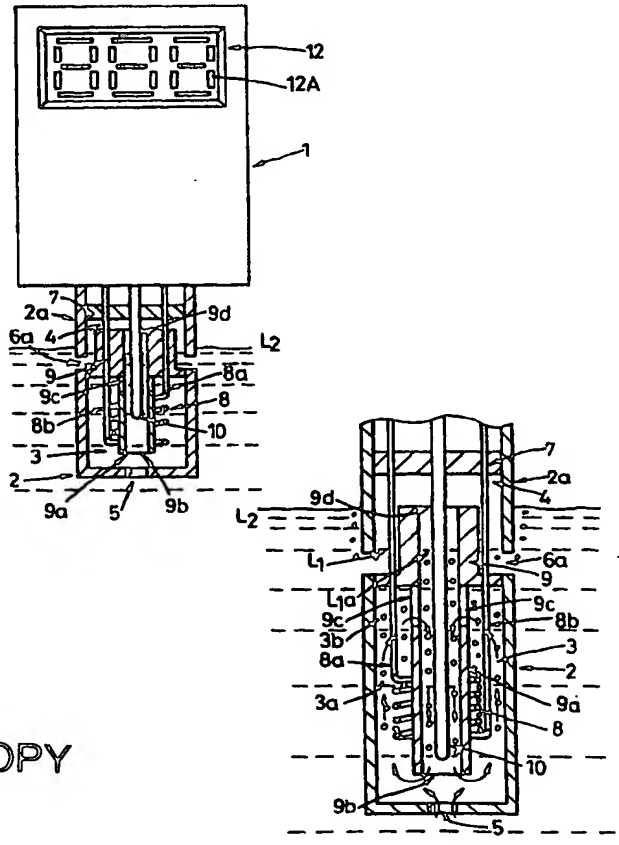
(54) Title: FLUID BOILING-POINT SENSING DEVICE

(57) Abstract

A Portable Fluid Boiling Point Sensing Device (1) which can be used to measure the boiling point of fluids. The device includes a probe (2) for immersion in fluid to be tested, in particular in a fluid reservoir. The probe (2) comprises a casing (2a) defining a chamber (3) for a semi-encapsulated portion of fluid (3a). The fluid (3a) kept at an optimum level without sensitive probe (2) depth measurement by a quantity of air (4) being trappped above the aperture means (6a) causing an artificial fluid level (L_1) to be maintained below the surface of the test fluid. A heater (8) and a temperature sensor (9) are presented in the housing (2a) and apertures (5, 6a, 6b) are provided to permit fluid flows into and from the chamber (3). The device senses the boiling temperature of the fluid by measuring the temperature of the vapours (11) given off the heated fluid (3a) within the housing (3), or alternatively directly from the fluid.



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FLUID BOILING-POINT SENSING DEVICE.

The present invention relates to a device for sensing the boiling point of a fluid and, more especially relates to a device for conveniently sensing the boiling point of hydraulic fluid, for example for testing the quality of brake fluid of a motor vehicle.

A hydraulic fluid such as motor vehicle brake fluid is hygroscopic, i.e. absorbs water (moisture). Water absorption has, of course, the effect of considerably reducing the boiling point of the fluid, with the result that in the case of motor vehicles, heavy vehicle braking may give rise to sufficient heat generation to boil the brake fluid thereby resulting in vapour entrapment in the fluid which could dangerously reduce braking performance.

Consequently, there is the need to test the quality brake fluid by sensing the boiling point of the fluid, so that the sensed value can be compared with an accepted standard to evaluate the fluid quality. Sensing devices are known for sensing the boiling point of fluid and especially the boiling point (and quality) of brake fluid. Basically, these devices include a heater to heat a quantity of the fluid to boiling point and a temperature sensor to sense the boiling temperature. Some of these devices, e.g. as shown in U.S. Patent 4 958 937, require a sample of fluid to be removed from the vehicle reservoir for testing, and the subsequent testing procedure is of a somewhat delicate laboratory-like nature. This is inconvenient and is not readily acceptable for everyday garage operations. To meet this problem, other sensing devices have been provided capable of testing directly at the fluid reservoir, an example of such a device being shown in U.S. Patent 4 484 823 (WO90 12311), but the arrangement of the heating means in the device of US-A-4 484 823 precludes prompt temperature sensing. The device shown in International Application WO90/12311 overcomes this problem by providing a hand-held sensor which, when inserted into the fluid to be tested, traps a small portionof the fluid in a semi-encapsulated chamber in a

probe part of the device for heating. The device, however, relied very much on correct depth immersion in the fluid. It is an object of the present invention to provide a fluid boiling-point sensing device which is capable of being hand-held and which can beused in a more convenient manner to sense the boiling points of fluids diectly at a fluid reservoir, e.g. in a vehicle brake fluid reservoir.

Therefore, according to one aspet of the present invention there is provided a fluid boiling-point measuring device as set out in the appended claim 1.

According to a second aspect of the present invention there is provided a fluid boiling-point measuring device as set out in appended claim 2.

Preferably control means including aperture means (6a) on the outer surface of the probe are provied to control the level (L_1) of the fluid in the housing for different degrees of immersion of the probe and further said control means serves to keep the test fluid in the housing at a set level by trapping a quantity of air within the probe above the aperture means such as to maintain a fluid/air boundary at a level (L_1).

Preferably the second aperture means are located below the bottom of the temperature sensor.

Preferably the prove member is of cylindrical form, said first and second parts defining cylindrical chambers, a plug being providd to close the top of the chamber of the second part. The probe member may comprise a single cylindrical casing, with said first aperture means located on a bottom wall of the casing. Alternatively the probe member may be of radially spaced double-wall form with said second aperture means on the outer wall and additional fluid aperture means on the inner wall located abve said second aperture means. Either of the first and second aperture means may comprise an electrical heater supplied with poer from an electrical battery while the temperature sensor which can comprise a thermocouple device if preferably linked to suitable monitoring and

presentation means for registering the measured temperature value. The probe member is preferably part of a self-contained hand-held unit.

In a preferred embodiment the fluid heating means are located around a central conduit, said central conduit having aperture means top and bottom and located within said conduit is a temperature sensor preferably of an electronic type. Said probe member further includes a second part located above said first housing part and open at the bottom so as to be in fluid communication with said first part via centre apertures, allowing fluid communication with the fluid within said conduit.

Said second part has second aperture means within the outer side wall (preferably cylindrical) for discharging of fluid air from the probe member to the reservoir and arranged so that when the said probe member is inserted into the reservoir fluid air is trapped in said closed topped second part to maintain a fluid boundary between said first and second parts. When the said probe is inserted into the fluid to be tested to a depth past said second aperture means and the said heating means operated, the fluid within the said first part is heated. Preferably the gap between the said outer side wall and the said central conduit allows the said heated test fluid only to rise, pulling cooler fluid from the base of said probe. By restricting the size of the first aperture means, the heated fluid is drawn down the conduit means causing a convection flow of the fluid being tested rising to the top of the first part of the probe and being drawn down the central conduit past the temperature sensor agitating the test fluid within the said first part. The fluid boundary between the first and second parts restricts the heated fluid transfer to the second part so causing its temperature to stabilise within the first housing part at boiling point. If the temperature within the first part were to rise to such a level that the boiling of the test fluid causes excessive gas bubbles within the first part, these excessive gas bubbles will be

vented via the fluid boundary through the second aperture meams. Cooler fluid from the reservoir is received into the first part via the first aperture means compensating for the evaporated test fluid within the first part and tending to stabilise the test fluid temperature at its relevant boiling point.

By the above arrangement, accurate testing of fluid in a reserviur is possible irrespective of the depth of immersion of the probe member in the fluid, provided that the second aperture means are below the level of the fluid in the reservoir.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings wherein:-

Fig. 1 shows a sectional elevation of a probe member of a brake fluid tester or analyser, in accordance with one embodiment of the present invention;

Figs. 2a and 2b show pictorial views illustrating the use of the tester of Fig. 1;

Fig. 3 shows a view similar to Fig. 1 of a second embodiment of the present invention; and

Fig. 4 shows a graph of the temperature of fluid under test and heated in the tester against time.

Figs. 5a and 5b show a sectional elevation of a probe member of a brake fluid tester or analyser, in accordance with a further embodiment of the present invntion.

Fig. 6 shows a view similar to Fig. 5a/b of yet a further embodiment of the present invention.

Referring to Fig. 1, a portable hand-held analyser or tester (generally indicated by ref 1) serves to sense the boiling temperature of a fluid, especially automotive brake fluid, so that the quality of the fluid can be established, the tester 1 including a prove member 2 for insertion into fluid to be tested. The probe member 2 comprises a lower part 3 and an upper part 4 thereabove, aperture means 5 at the bottom of the prove permitting fluid flow into the part 3, and aperture means 6a for discharge of fluid from the probe membr 2. The top of

the aperture means 6a whereat a fluid level L, is established in the member 2 generally defines the demarcation line between the lower and upper parts 3, 4 the upper part 4 being in fluid communication with the lower part 3. The member 2 is of cylindrical form so that the parts 3, 4 comprise cylindrical chambers or housings.

The upper part 4 is closed at its top end by a plug 7. The lower part 3 houses an electrical heating element 8 the leads 8a, 8b of which pass sealingly through the plug 7 while a temperature sensor 9 is located in the part 4 so that the sensor bottom end is just above the L, and serves for measuring the boiling point of fluid heated in the part 3, the sensor 9 also passing sealingly through the plug 7.

Fig. 3 shows a similar arrangement but with double cylindrical walls 2a, 1b providing insulation for the housing part 3. The inner wall 2a includes aperture means 6b at the upper end whereby gas vapour 11 emitted from fluid under test in the housing 3 and passing from surface L, can flow to the aperture means 6a via the annular passage between the walls 2a, 2b. The aperture means 6a preferably comprise a plurality of individual ports 6a (in particular at least four) arranged around the circumference of the wall 2b at approximately the same level: this enables the device 1 to operate even whe tilted (as shown dashed in Fig. 2a) up to 45^{o} from the vertical.

The temperature sensor 9 can comprise a thermocouple device which is linked to electronic measurement processing equipment housed in a display unit 12. Such electronic processing equipment is well established and consequently need not be described in detail; the equipment (and the heater 8) can be powered by self-contained rechargeable batteries or alternatively leads can be included to couple the equipment to a separate battery e.g. the motor vehicle battery. The temperature measurement is show on a display 12a of the unit 12.

Additionally the equipment includes a latching device responsive to the rising temperature measurement of the thermocouple 9 (in this case the temperature of the vapour 11), and the latching device is such that as the temperature rise reduces and stabilises as the boiling temperature is approached and reached (as shown in Fig 4) the device latches to the stabilised temperature and this is indicated on display 12A.

A significent feature of the device 1 is the provision of a closed air space 4 between the upper plug 7 and the level at the apertures 6a, this space 4 effectively providing an air buffer which enables the device 1 to enjoy several significant characteristics, namely:-

a) The device is not excessively immersion depth sensitive as the level L, of the test fluid in the probe 2 can be maintained substantially uniform for varying degrees of probe immersion as shown in Figs. 2a and 2b.

b) Fluid disturbance in the probe 2 of the device 1 is minimised due to the air buffet absorbing fluid pressure fluctuations in the probe thereby preventing escape of hot fluid from the probe.

c) The air buffer provides thermal insulation between the hot fluid in the housing 3 and the processing equipment in unit 12.

The aperture 5 or apertures in the base of the probe 2 preferably have a size which allows the fluid to flow timeously into the test housing 3 while restricting the flow of oxygen in the probe 2. The advantage of this is that if the device were inadvertently operated when outwith the fluid reservoir i.e. with the probe in air the possibility of the residue fluid within the probe being set alight is avoided or reduced.

In the embodiment of Figs. 5a/5b where the boiling point temperature is sensed somewhat differently, a portable hand-held analyser or tester (generally indicated by ref 1, again includes a probe member 2 comprising a lower part 3 and an upper part 4 thereabove, aperture

means 5 permitting fluid flow into the part 3, and aperture means 6a for discharge of fluid from the probe member 2 within the upper part 4 level. The top of the aperture means 6 whereat a fluid level L, La is established in the member 2 generally defines the demarcation line between the lower and upper parts 3, 4, the upper part 4 being in fluid communication with the lower part via aperture means 9d in a plug 9. The member 2 is of cylindrical form so that the parts 3, 4 comprise cylindrical chambers. The upper chamber 4 is closed at its tope end by a plug 7. The lower chamber 3 houses an electrical heating element 8 and its leads (8, 8b which pass sealingly through the plug 7 and a second plug 9 serving to separate the upper chamber 4 and lower chamber 3., Extending from the base of the second plug 9 is a conduit 9a with lower aperture 9b. Apertures 9c are level with the top of the lower chamber 3 and the upper chamber 4 and lower chamber 3 are fluidly connected through aperture 9d. A temperature sensor 10 is located within the conduit 9a and serves for measuring the boiling point of fluid heated in the lower chamber 3, as shown in Fig. 5b. The heated fluid 3a rises and causes the same heated fluid to be drawn down the central conduit 9a via apertures 9c, 9b so that fluid recirculation is established. The temperature within this circulating fluid 3a stabilises at the boiling point. Excessive steam bubbles 3b if created within the lower chamber 3 vent through the fluid boundary L, La and aperture 6a, cooler fluid from the reservoir being drawn in through aperture 5 helping to stabilise the fluid's 3a temperature.

The embodiments of Figs. 5a/b and Fig. 6 also employ the air buffer 4 of the Fig. 1 embodiment and a temperature measurement processing equipment in a display unit 12 and including a latching device is again provided, temperature measurements and latching in this case being taken directly from the fluid rather than from the emitted vapour as in the earlier embodiments.

Instead of the combined display unit 12 and probe 2, it would be possible to have a remote display unit 12 connected to the probe 2 by cable means.

In Figs. 1 and 3, the bottom of the temperature sensor may extend slightly below the surface L, of the test fluid in housing 3 but nevertheless for the sensor to be essentially responsive to the temperature of the emitted vapour 11.

CLAIMS

1. A fluid boiling point measuring device for indicating the boiling point of fluid, especially a hygroscopic fluid such as hydraulic fluid, comprising a meter (1) preferably of the portable hand held type including a probe (2) for insertion into fluid in a fluid reservoir, heating means (8) being provided in the probe (2) for heating fluid within the probe (2) when the probe (2) is immersed, said meter additionally including monitoring means (10) for monitoring the temperature rise of fluid heated by said heating means (8) so as to indicate the boiling point temperature of the fluid (3a), characterised in that said probe (2) includes a casing (2a) defining a housing (3) wherein a portion of fluid to be tested is held, in that the temperature monitoring means (10) senses the temperature of the fluid (3a) in the housing (3) heated by the heating means (10) and in that fluid inlet means (5, 6a, 9c, 9d) are provided permitting fluid flows to and from the housing (3).

2. A fluid boiling point sensing device for indicating the boiling point of fluid, especially a hygroscopic fluid such as hydraulic fluid, comprising a meter (1) preferably of the portable hand held type including a probe (2) for insertion into fluid in a fluid reservoir, heating means (8) being provided in the probe (2) for heating fluid in a test zone within the probe (2) when the probe (2) is immersed, said meter additionally including monitoring means (9) for monitoring the temperature rise of fluid heated by said heating means (8) so as to indicate the boiling point temperature of the fluid, characterised in that said probe includes a casing (2a) defining a housing (3) wherein a portion of fluid to be tested is held, in that the temperature monitoring means (9) is located adjacent the level (L_1) of the test fluid in

the housing (3) and in that fluid port means (5, 6a, 6b) are provided permitting fluid flows to and from the housing (3).

3. A fluid boiling point sensing device as claimed in Claim 1 or Claim 2, characterised in that control means (4, 6a) including aperture means (6a) on the outer surface of the probe (2) are provided to control the level (L_1) of the fluid in the housing (3) for different degrees of immersion of the probe (2).

4. A fluid boiling point sensing device as claimed in Claim 3, characterised in that said control means (6a, 4) serves to keep the test fluid in the housing (3) at a set level by trapping a quantity of air within the probe (2) above the aperture means (6a) such as to maintain a fluid/air boundary at a level (L_1).

5. A fluid boiling point sensing device as claimed in Claim 2, characterised in that the temperature measuring device (9), preferably a thermocouple, is positioned to monitor the temperature of the gasses (11) given off the test fluid (3a) as the fluid is heated by the element (8) in the lower portion of the probe (2).

6. A fluid boiling point sensing device as claimed in Claim 2 or 5, characterised in that there is provided a display means (10), wherein the temperature of the gasses (11) given off from the fluid on test (3a) as it is heated by the heater (8) and measured by the monitoring means (9) are indicated.

7. A fluid boiling point sensing device as claimed in Claim 6, characterised in that the display means (10) incorporate electronic sensing means.

8. A fluid boiling point sensing device as claimed in Claim 2, 5, 6 or 7, characterised in that there is provided a latching device, which senses the rise in temperature of the gasses (11) emitted from the fluid (3a) being tested as the fluid is heated by the heater (8), such that as the temperature rise lessens, then levels as the test fluid boiling point occurs, this stabilised temperature is latched on within the device and the corresponding temperature is indicated until the device is switched off or the next test sequence begun.

9. A fluid boiling point sensing device as claimed in any one of the preceding claims, characterised in that a housing, preferably cylindrical, provides a chamber (3) within the probe with aperture means in both the base (5) and the sidewall (6a, 6b) of the housing, the apertures in the base (5) allowing the fluid to be tested to flow into the test chamber when the probe is immersed in a reservoir fluid with a level (L_2), and also allowing the test fluid to flow from within the probe when the probe is withdrawn from the fluid.

10. A fluid boiling point sensing device as claimed in Claim 9, characterised in that the apertures (5) in the base are of a size which allows the fluid to flow timeously into the test chamber (3) while restricting the flow of oxygen to the heating element (8) within in the probe (2) thereby preventing any residue fluid within the probe being set alight if the device is inadvertently operated whilst in air and not in the test fluid.

11. A fluid boiling point sensing device as claimed in Claim 9, characterised in that the apertures (6a) in the side of the probe are located to trap a quantity of air in the upper part (4) within the probe (2)

creating a thermal buffer between the heated test fluid (3a) and control and display electronics (10).

12. A fluid boiling point sensing device as claimed in Claim 2, characterised in that the housing (3) is formed solely by the outer casing (2a) of the probe (2).

13. A fluid boiling point sensing device as claimed in Claim 2, characterised in that the probe (2) comprises radially spaced inner and outer casings (2a, 2b), the housing (3) being formed by the inner casing (2a), and in that the inner casing (2a) includes aperture means (6b) which are located above the level of aperture means (6a) on the outer casing (2b).

14. A fluid boiling point sensing device as claimed in Claim 1, characterised in that recirculating means (9a, 9b, 9c) are provided whereby the test fluid recirculates in the housing (3) when heated by the heating means (8).

15. A fluid boiling point measuring device as claimed in Claim 14, characterised in that inner casing means in the housing (3) defines a central conduit (9a), the recirculation means being such that the fluid between the outer probe wall (2a) and said central conduit (9a) rises drawing fluid from the base of the probe (2) and down said central conduit (9a) via apertures (9c, 9b), the temperature monitoring device (10), preferably a thermocouple, measuring the temperature within the test fluid (3a) in its housing, the arrangement being such that as the boiling point is reached the fluid circulating effect in the housing (3) ceases and the fluid temperature rise in the housing (3) stabilises enabling the boiling point of the test fluid to be ascertained.

16. A fluid boiling point measuring device as claimed in Claim 14 characterised in that there is provided a display means (11), preferably incorporating an electronic sensing means, wherein the temperature of the fluid on test (3a) in the housing as it reaches boiling point can be indicated.

17. A fluid boiling point measuring device as claimed in Claim 11, characterised in that there is provided a latching device, which senses the rise in temperature of the fluid (3a) in the housing (3) being tested as it is heated, as the temperature rise lessens, then levels as the test fluid boiling point occurs, this stabilised temperature being latched on by the device and the corresponding temperature is shown on the display (11) until the device is switched off or the next test sequence begun.

18. A fluid boiling point measuring device as claimed in any of the preceding claims, characterised in that the probe (2) when immersed in the test fluid past the probe apertures (6a) in the outer probe casing becomes largely insensitive to the depth of fluid being tested until immersed to such a level that the pressure within the fluid in the housing (3) starts to compress an air pocket (4) in the probe above the fluid thereby altering the fluid air boundary (L_1).

19. A fluid boiling point sensing device as claimed in Claim 15, characterised in that a plug (9) is located between the lower housing (3) and an upper chamber (4) in the probe (2), the plug (9) having a through aperture (9d) for fluid communication between the housing (3) and the upper chamber (4), the aperture (6a) on the outer wall of the probe (2) being located adjacent one side of the plug (9) and communicating with said upper chamber (4) while an upper aperture

means (9c) in said inner casing of the central conduit (9a) is located adjacent the other side of the plug (9) so as to mitigate against the formation of a hot spot of fluid adjacent to the fluid/air boundary (L, a) between the housing (3) and the upper chamber (4).

20. A fluid boiling point sensing device as claimed in Claim 19, characterised in that the plug includes a radial flange portion adjacent the aperture (6a) in the probe casing and an elongate neck portion extending upwardly from the flange portion into said upper chamber (4).

21. A fluid boiling point sensing device as claimed in Claim 15 or Claim 19, characterised in that the heater (8) comprises a heating coil surrounding said inner casing (2b).

22. A fluid boiling point measuring device as claimed in Claim 19, characterised in that during the operation of the device (1), test fluid (3a) is heated by the heater (8), and circulates upwards between the outside wall (2a) of the probe (2) and downwards within the central conduit (9a), the test fluid (3a) circulating until the fluid temperature is uniform within the housing (3), a fluid air pocket in the upper chamber (4) serving to create a thermal buffer (L1a) at a fluid level (L_1), so that when the test fluid (3a) rises above the boiling point temperature within the housing (3), resulting excess vapour vents through the aperture (9d) in the plug and through the aperture (6a) in the probe outer wall while cooler fluid enters through a lower aperture (5) in the probe, tending to stabilise the test fluid (3a) at its boiling point temperature.

23. A fluid boiling point measuring device as claimed in Claim 19, characterised in that the probe (2) comprises a single cylindrical casing (2a) forming the outer wall of the upper and lower chambers (3, 4) and is supplemented by a further radially spaced double wall casing (2b) with the space between the casings (2a, 2b) sealingly closed at their upper end by a further plug (7), the aperture (6a) on the outer casing being arranged to position the air/fluid boundary (L_1) of the chambers at an optimum.

24. A fluid boiling point sensing device a claimed in any one of the preceding claims, characterised in that an air buffer is provided in an upper zone (4) of the probe (2), said air buffer serving to absorb fluid pressure fluctuations in the probe to preclude escape of hot fluid from the probe thereby minimising fluid disturbance of the probe (2).

25. A fluid boiling point sensing device as claimed in any one of the preceding claims, characterised in that a plurality of apertures (6a) are arranged around the outer wall (2b) of the probe (2) at substantially the same level and at the heater (8) enabling the sensing device to operate when inclined with a probe angle up to 45^{o} from the vertical.

26. A fluid boiling point sensing device as claimed in claim 25, characterised in that at least for apertures (6a) are provided on the outer wall (2b) of the probe (2).

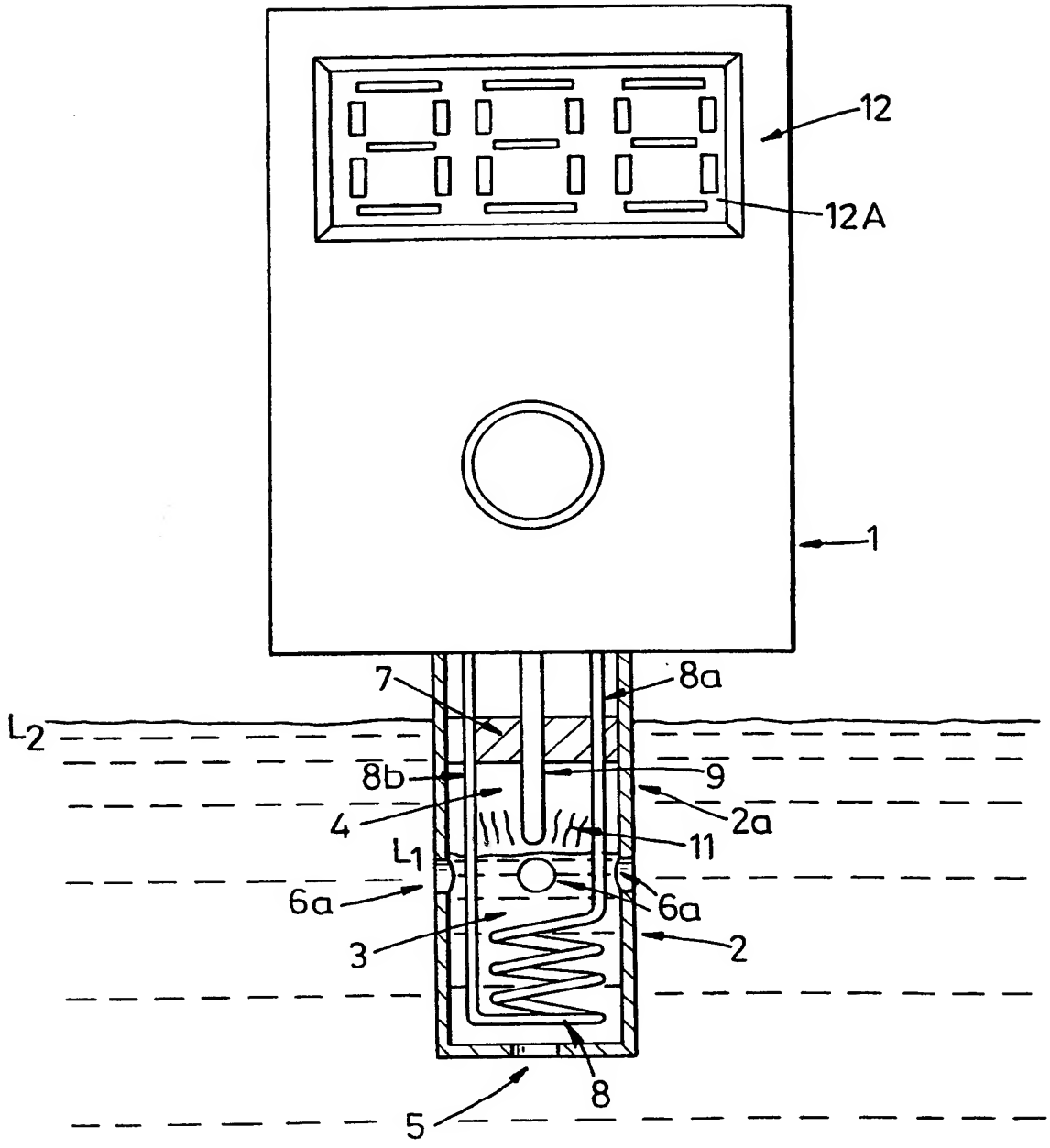

Fig. 1

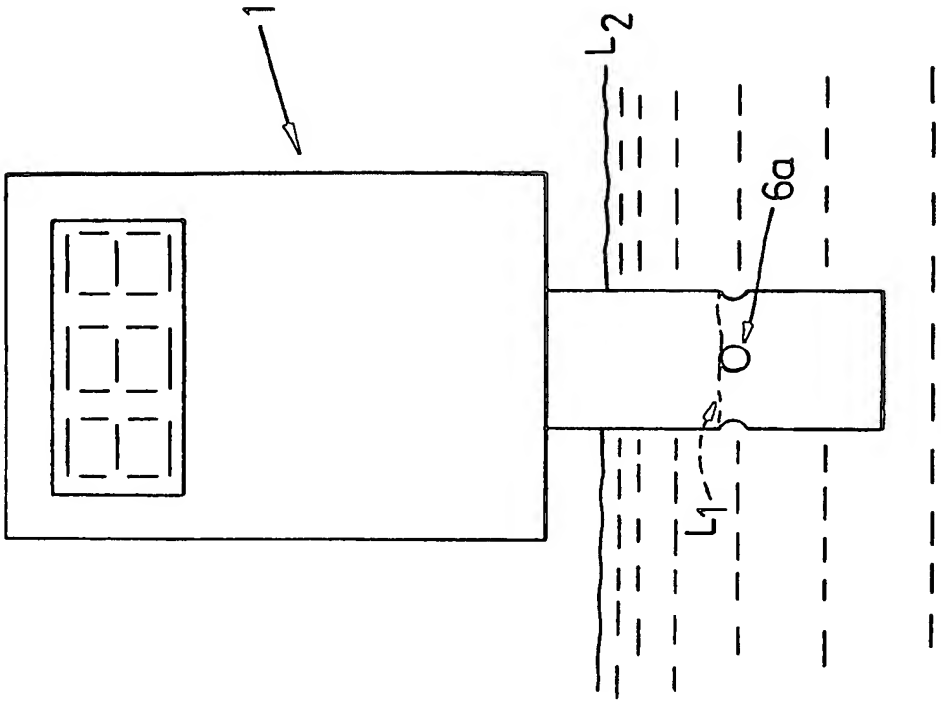

Fig. 2b

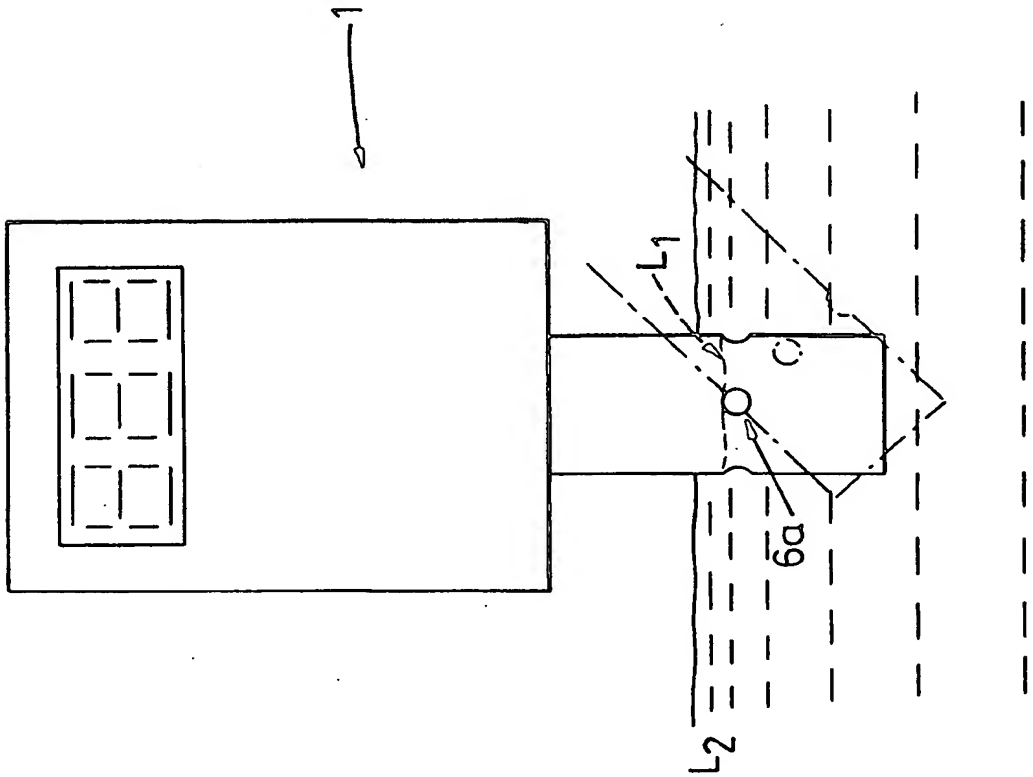

Fig. 2a

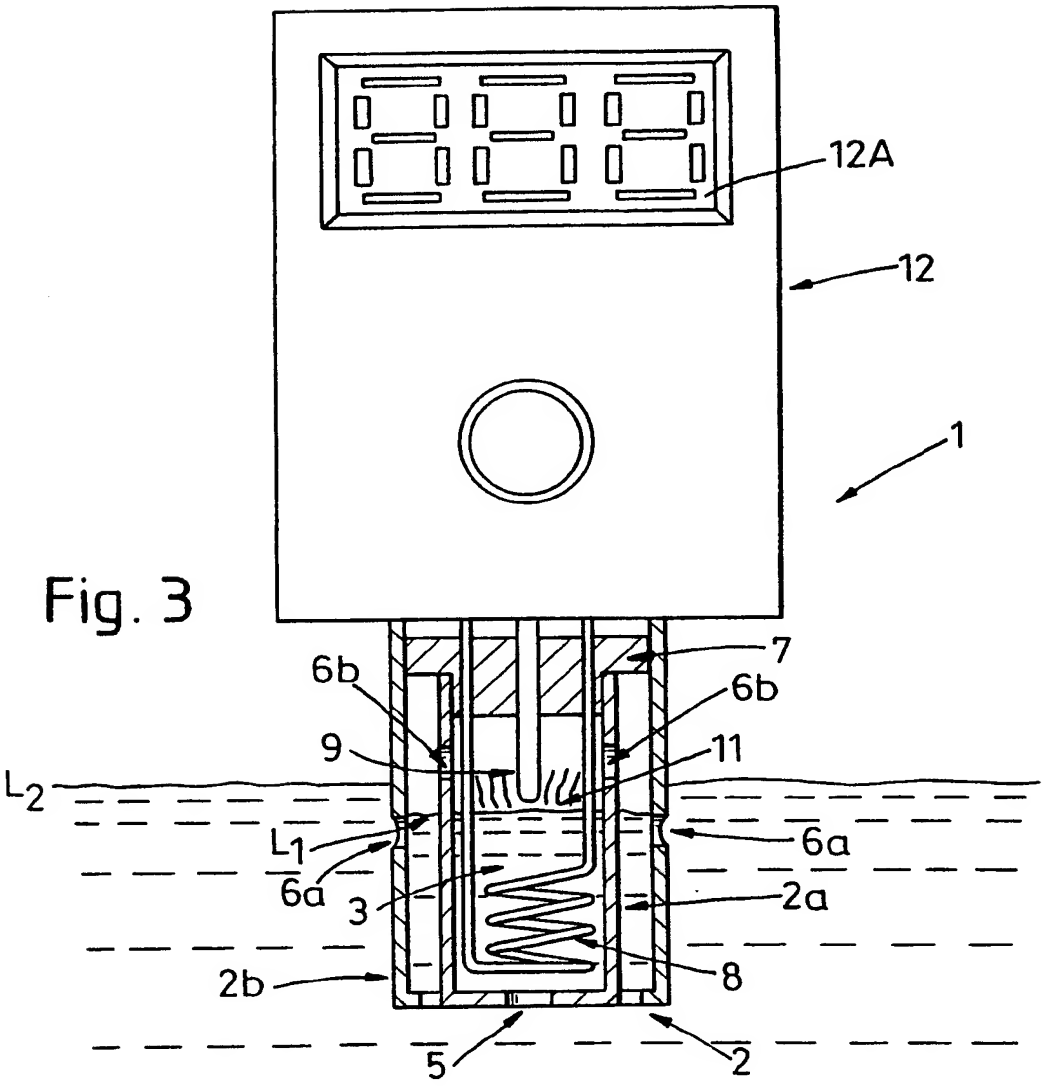

Fig. 3

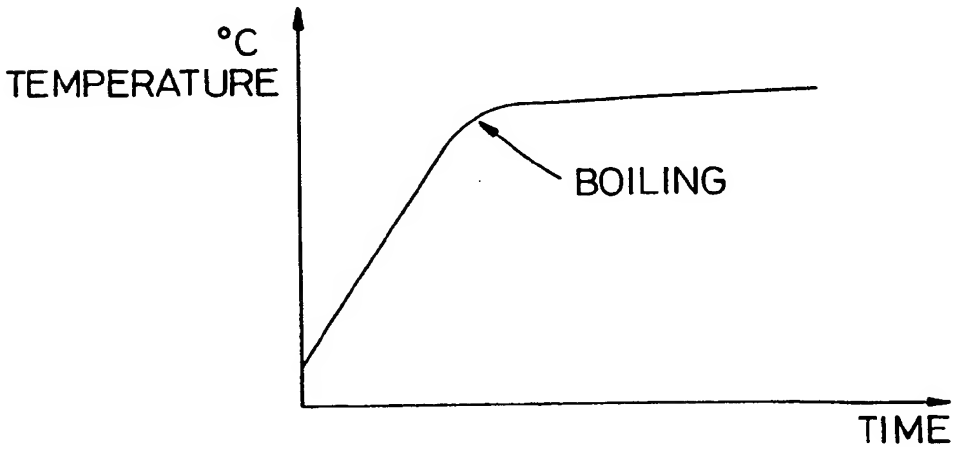

Fig. 4

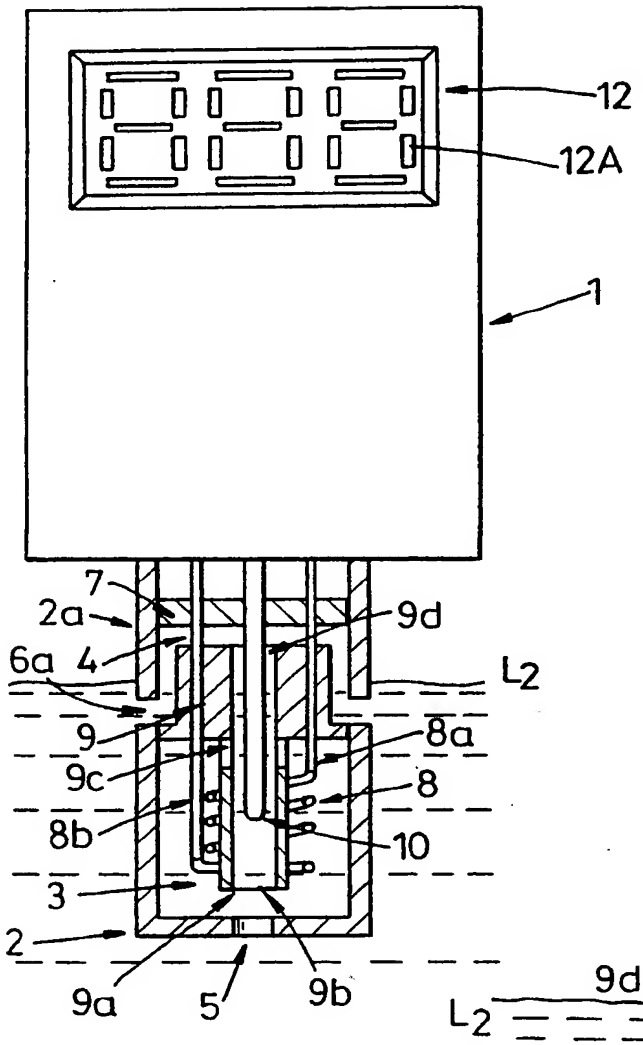

Fig. 5a

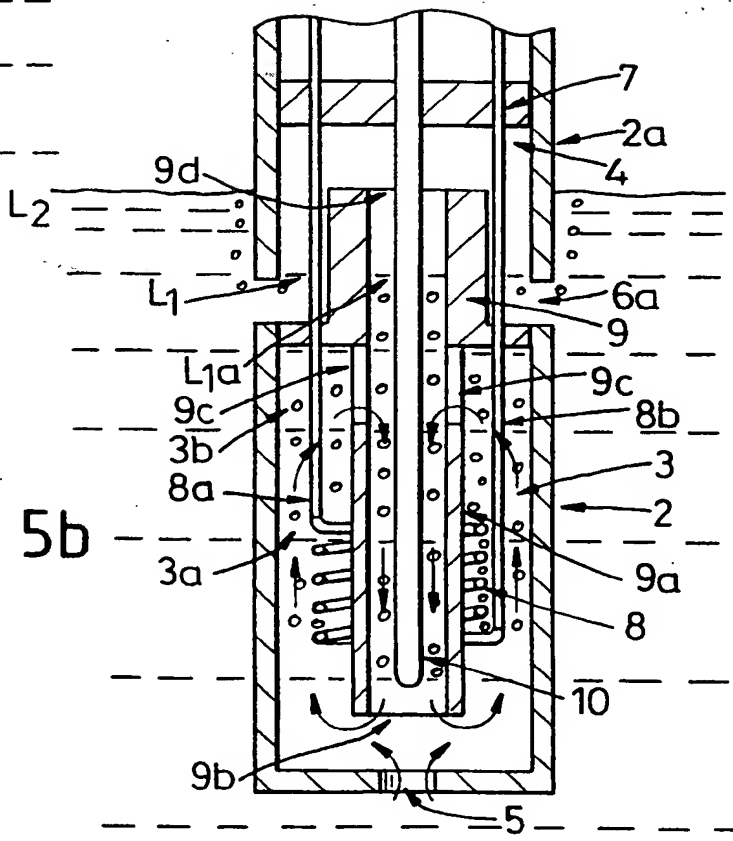

Fig. 5b

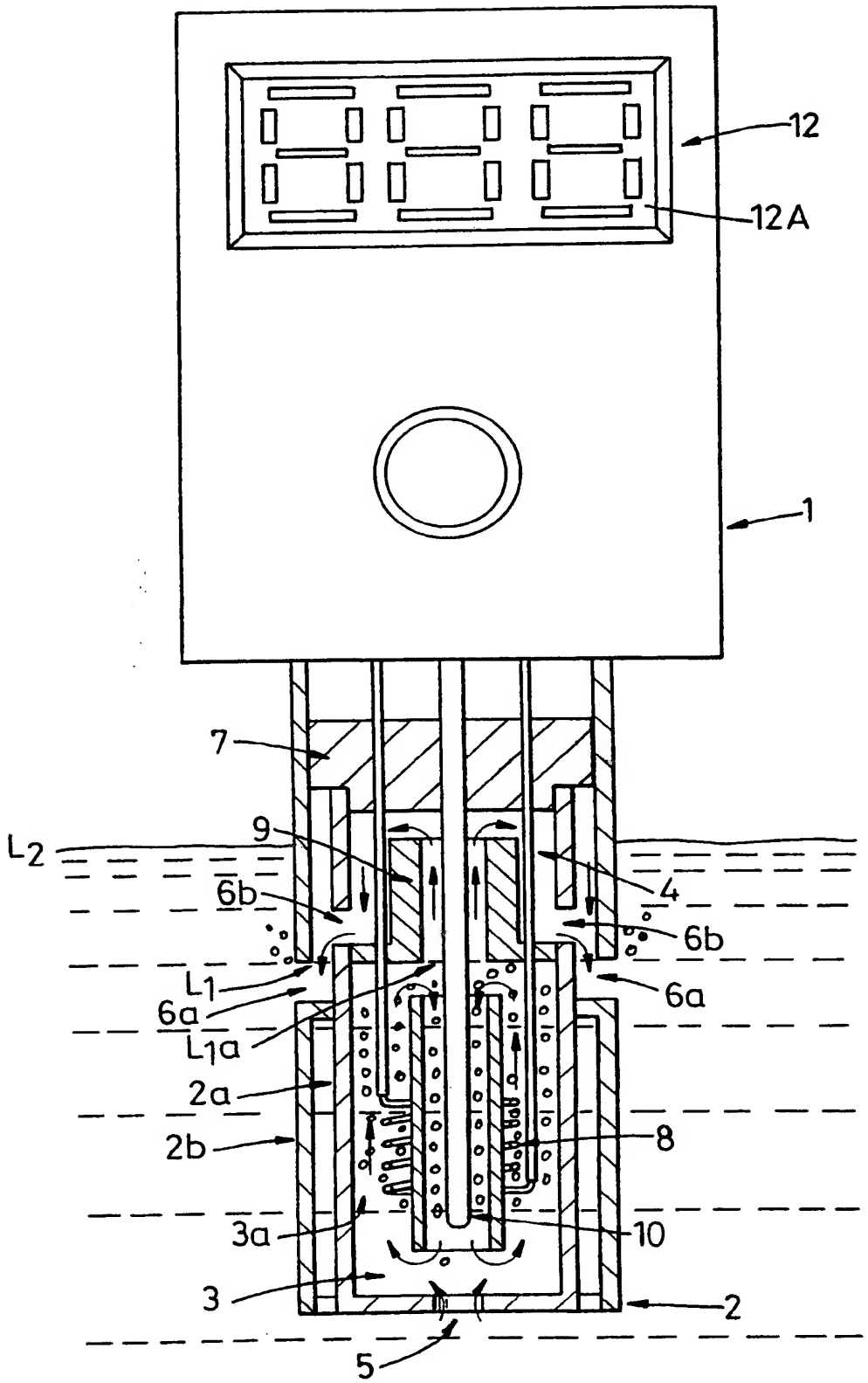

Fig. 6

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

Inten ial Application No
PCT/GB 95/00543

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01N33/28 G01N25/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,90 12311 (LIQUID LEVERS (INNOVATIONS) LTD) 18 October 1990 cited in the application	1,9,10
A	see the whole document	2-8, 11-26
A	FR,A,2 338 489 (WINTER, HORST H.) 12 August 1977 see figure 1	4,11,18, 24

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 June 1995	06.07.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Bosma, R

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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 95/00543

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